DOCUMENT RESUME

ED 258 406 EC 172 926

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TITLE Facilitating the Acquisition of Science Classifications in Learning-Disabled Students.
PUB DATE Apr 85
NOTE 40p.; Paper presented at the Annual Meeting of the American Educational Research Association (69th, Chicago, IL, March 31-April 4, 1985).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Classification; Junior High Schools; *Learning Disabilities; *Mnemonics; *Science Education; *Teaching Methods

ABSTRACT

Learning-disabled junior high school students (N-36) were taught three dichotomous classifications for each of eight minerals; hardness level (hard-soft), color (pale-dark), and common use (home-industry). Ss were randomly assigned to three experimental conditions in order to learn this information. In the direct instruction condition, Ss were taught the mineral classification according to the principles of direct instruction (i.e., student participation with repeated practice and reinforcement). In the mnemonic instruction condition, Ss were shown thematic illustrations that integrated each of the minerals and its symbolized attribute classifications. In the free-study condition, Ss were instructed to learn the eight minerals however they wished. It was found that Ss who learned via mnemonic instruction outperformed those who were allowed free study, who in turn outperformed direct instruction students. Implications for classroom instruction are indicated. (Author/CL)

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Facilitating the Acquisition of Science Classifications in Learning-Disabled Students

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Running head: SCIENCE CLASSIFICATIONS

Paper presented at the annual meeting of the American Educational

Abstract

Learning-disabled junior high school students were taught three dichotomous classifications for each of eight minerals: hardness level (hard-soft), color (pale-dark), and common use (home-industry). Thirty-six students were randomly assigned to three experimental conditions in order to learn this information. In the direct instruction condition, students were taught the mineral classifications according to the principles of direct instruction (viz., student participation with repeated practice and reinforcement). In the mnemonic instruction condition, students were shown thematic illustrations that integrated each of the minerals and its symbolized attribute classifications. In the free-study condition, students were instructed to learn the eight minerals however they wished. It was found that students who learned via mnemonic instruction outperformed those who were allowed free study, who in turn outperformed direct instruction students. Implications for classroom instruction are indicated.

Facilitating the Acquisition of Science Classifications in Learning-Disabled Students

It is commonly agreed that recall of information is critically important for success in school and later in life. Learning-disabled (LD) students have been identified as a group that may benefit greatly from improved skills in recalling such information. In fact, LD students have been described as exhibiting deficiencies in short-term memory, long-term memory, and spontaneously produced memory strategies (Hallahan & Reeve, 1980; Torgesen & Kail, 1980). Worden (1983) has reviewed literature that addresses the issue of strategy training for LD students.

"Mnemonic" instruction, which consists of systematic techniques specificially designed to improve memory, has only very recently been investigated in LD populations. One such mnemonic technique is the "keyword method" (Atkinson, 1975). The keyword method contains what Levin (1983) has referred to as the "three R's" of associative mnemonic techniques: recoding, relating, and retrieving. For example, in studying mythology, it may be important to remember that Zeus was the king of the gods. To learn this information by the keyword method, the learner first recodes the stimulus, Zeus, into a familiar, easily pictured, similar-sounding "keyword". In this case, zoo might be a good keyword because it is easily pictured and sounds much like the

stimulus Zeus. In the relating stage, the learner relates the transformed stimulus, zoo, to the to-be-associated response, king, via an interactive picture. In this case, a king could be pictured in a zoo (see Figure 1). With the final retrieving component, when the learner is asked about Zeus, (s)he is

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Insert Figure 1 about here

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reminded of the keyword zoo, which leads to the picture of the zoo with a king in it, which in turn produces the appropriate response, king. The effectiveness of the keyword method has been examined experimentally in many studies involving adults and school-age children (see Pressley, Levin, & Delaney, 1982, for a review). The method has consistently yielded substantial increases in students' recall of factual information, including English vocabulary (e.g., Levin, Johnson, Pittelman, Hayes, Levin, Shriberg, & Toms-Bronowski, in press), foreign language vocabulary (e.g., Pressley & Levin, 1978), states and capitals (e.g., Levin, Shriberg, Miller, McCormick, & Levin, 1980), famous people (e.g., Jones & Hall, 1982), and expository prose passages (e.g., Levin, Shriberg, & Berry, 1983). These investigations have documented the superiority of mnemonic instruction relative to a variety of instructional alternatives.

Recently, Mastropieri, Scruggs, and Levin (in press b) investigated the effectiveness of mnemonic instruction in an LD

adolescent population. Students were randomly assigned to one of three conditions where they learned the hardness levels of North American minerals according to Moh's scale (e.g., barite equals 3 on the hardness scale). In the mnemonic condition, students were first taught rhyming "pegwords" for the numbers 1 through 10 (1 = bun, 2 = shoe, 3 = tree, etc.)--see Paivio (1971). Next they were taught keywords for each of the mineral names (e.g., bar for barite). They were then shown an illustration of the keyword and the pegword interacting. For example, for barite, students were shown a picture of a bar in a tree (see Figure 2). In the free-study condition, students were provided with the minerals and

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Insert Figure 2 about here

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hardness levels in a list format and were given an equal amount of time to study on their own. In the direct-questioning condition, realistic line drawings of the minerals were provided, and the students were repeatedly questioned by the experimenter about the minerals and their hardness levels. The results indicated that LD students instructed mnemonically recalled significantly more mineral hardness levels than did students in either of the other two conditions. In addition, students in the free-study condition were found to recall more than students in the direct-questioning condition.

The direct-questioning condition employed in the Mastropieri et al. (in press b) study was designed to control for the effects of interaction with the experimenter; it did not, however, contain certain critical elements of direct instruction (Rosenshine, 1979), such as pacing and cumulative review. For that reason, a followup study was conducted (Mastropieri, Scruggs, & Levin, in press a) in which mnemonic instruction and direct instruction were directly compared on the hardness-of-minerals task. In Experiment 1 of that investigation, LD students who had been instructed mnemonically significantly outperformed students in the direct instruction condition. In Experiment 2, educable mentally retarded (EMR) students were taught the hardness levels of minerals by both mnemonic and direct instructional procedures in a crossover design. Every student remembered more hardness levels when in the mnemonic instruction condition than when in the direct instruction condition.[1]

As a followup to the Mastropieri et al. (in press a) study, Scruggs, Mastropieri, Levin, and Gaffney (in press) sought to determine whether mnemonic instruction would lend itself to teaching LD students more than one attribute per mineral. Recent successful mnemonic prose-learning attempts with nondisabled students suggested that it might (e.g., Levin et al., 1983; McCormick & Levin, 1984). In the present context, for example, rather than teaching that pyrite is No. 6 on the hardness scale,

it might be important to teach simultaneously that pyrite is No. 6 on the hardness scale, is yellow in color, and is used in the manufacture of acid. To acquire this information mnemonically, LD junior high school students were first taught the keyword for pyrite (pie) and then shown an illustration of some pie interacting with its hardness level pegword (6 = sticks), its color (yellow), and its use (acid). Thus, a yellow pie was shown supported by sticks while acid was being poured on it--see Figure 3.

Insert Figure 3 about here

Three other conditions were included in this investigation: a free-study condition (in which the children studied on their own from a listing of the attributes as they would appear in a textbook) and two direct instruction conditions. In the first direct instruction condition, students were given direct instruction in the eight minerals and their attributes for the same amount of time associated with the mnemonic and free-study conditions. However, because some would argue that too much information may have been presented in too short a time for direct instruction, a second (reduced-list) direct instruction condition was included in which students were given the same amount of time to study only four of the eight minerals. Results indicated that

performance of students in the mnemonic condition was superior to that in the two other full-list conditions. Moreover, on the average, mnemonic students were able to learn as much about 17 mineral attributes as reduced-list direct instruction subjects were able to learn about 6 mineral attributes in the same amount of time. Finally, it was found that the performance of direct instruction subjects tended to be worse (though not statistically so) in comparison to that of free-study subjects. The relatively poor showing of direct instruction in both the Scruggs et al. (in press) and the previously cited studies must be seriously reckoned with by those who have advocated the widespread classroom application of that approach for handicapped learners (e.g., Becker, Engelmann, Carnine, & Maggs, 1982).

The results of the Scruggs et al. (in press) investigation indicate that several specific attribute values of minerals can be taught effectively according to a mnemonic procedure. In particular, the mnemonic procedure was associated with the learning of specific hardness levels (1-10), specific colors (e.g., red, yellow, black), and specific uses (e.g., acid, light bulbs, mixing metals). Much classroom learning, however, does not require that students recall specific attribute values; rather, only taxonomic classifications (frequently as dichotomies) are all that is required. For example, students might be asked not specific attributes of the United States, but northern versus

southern states, warm versus cold states, industrial versus agricultural states, etc. Similarly, in a unit on animals, the task might be to classify instances as mammals versus non-mammals, vertebrates versus invertebrates, carnivores versus herbivores, etc. In the present context, a question that logically follows from the Scruggs et al. (in press) study is: How would the three instructional procedures (mnemonic instruction, direct instruction, and free study) compare if LD students were required simply to classify the previous mineral attributes in a dichotomous fashion (i.e., hard versus soft for hardness level; pale versus dark for color; and home versus industry for common use)? The answer to this question is not obvious, inasmuch as different plausible outcomes can be argued.

For example, it is certainly possible to incorporate symbolic pictorial representations into the present mnemonic approach for teaching the mineral attributes (e.g., a picture of an old man and a baby to represent hard and soft minerals, respectively), and such mnemonic symbolizations have previously proven effective with both college students (e.g., Desrochers, 1982) and nondisabled junior high school students (e.g., Levin et al., 1983). However, such repeated symbols (i.e., four "old man" minerals and four "baby" minerals) may well constitute a source of difficulty for LD students. In particular, are mnemonically symbolized attributes salient and distinct enough for LD students to benefit

from them? Moreover, perhaps either of the two other alternative instructional procedures (direct instruction or free study) is better suited to the coding and recall of attribute dichotomizations than of specific attribute values. Of particular interest was how direct instruction would fare in the present mineral classification situation. The purpose of the study, then, was to determine: (a) whether the mnemonic instructional procedure of the Scruggs et al. (in press) investigation could be effectively adapted to LD students' learning of multiple attribute classifications; and (b) whether the pattern of differences among the three instructional conditions would parallel that observed by Scruggs et al.

Method

Subjects

Thirty-six seventh- and eighth-grade students participated in the study. All students were classified as LD according to local school criteria and Public Law 94-142. The five girls and 31 boys ranged in age from 14 years, 8 months, to 12 years, 5 months, with a mean age of 13 years, 10 months (SD = 7 months). Wechsler Intelligence Scale for Children-Revised scales ranged from 78 to 103, with a mean of 91.75 (SD = 7.1). The mean California Achievement Test grade equivalent for total reading was 5.82 (SD = 1.9). Students were first stratified by grade level and then randomly assigned in equal numbers to the three experimental

conditions: mnemonic, direct instruction, and free study.

Materials

Students in all three conditions were taught the same list of ten minerals and attributes. Eight of the items constituted the target list of minerals and attributes, with two of the items making up the practice list. The materials specific to each condition will now be described.

Mnemonic condition. For each mineral and attribute combination, an 8-1/2" x 11" black-and-white line drawing was constructed. Each illustration had a representation of the keyword interacting with a home or factory scene (depicting the particular use of that mineral), a baby or an old man (baby depicting soft mineral, old man depicting hard mineral), and the keyword figure was either blackened in or not blackened in (blackened in for dark color, not blackened in for pale color). For example, the mineral pyrite depicted a picture of an old man with some pies in a factory scene (see Figure 4). The pies represent pyrite, the old man represents a hard mineral, and the factory scene stands for use in industry. In addition, the pies

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Insert Figure 4 about here

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are not blackened in to represent pyrite's pale color. As another example, crocoite, a soft, dark mineral used in the home, was

represented by a picture of a crocodile (the keyword for crocoite) in a home scene with a baby (see Figure 5). The home scene stands for the fact that crocoite is used in the home, the baby represents the fact that crocoite is a soft mineral, and in addition, the crocodile is blackened in to represent the fact that crocoite is dark in color.

Insert Figure 5 about here

Direct instruction condition. Ten black-and-white line drawings on 8-1/2" x 11" paper were also used as materials for each of the minerals and associated attributes in the direct instruction condition. In this case, however, each line drawing represented the mineral itself. For pyrite, for example, the line drawing was a realistic representation of pyrite that was pale in color. Above the picture was written: "pyrite, hard mineral, pale color, used in industry", as in Figure 6.

Insert Figure 6 about here

Free-study condition. Students in this condition were supplied a single sheet of 8-1/2" x 11" paper that had the eight mineral names and associated attributes on it. The four soft minerals were listed first, followed by the four hard minerals.

In addition, a typed sheet containing the two practice items was also prepared.

Procedure

All students were seen individually by a female experimenter in a quiet room in the students' school, and all were with the experimenter for an equal amount of time. The students were told they were about to learn some information about minerals, that they should try hard, and that they would be given a quiz on the information at the end of the session. The instructions specific to each condition will now be described.

Mnemonic condition. Students in the mnemonic condition were initially taught keywords for the two practice items. They were then taught that a baby represented a soft mineral and an old man represented a hard mineral, and that a home scene or a factory scene represented the use of that particular mineral. In addition, they were taught that a nonblackened-in keyword figure represented a light-colored or pale mineral, whereas a blackened-in keyword figure represented a dark mineral. Following this, students were shown the two practice illustrations and taught how to retrieve the information. Then a practice quiz was given in order to allow the students to practice the retrieval process. Students were then taught the keywords for the eight target items. Immediately following this, students were shown each of the target illustrations for 30 seconds per picture and were told, for

example: "Pyrite is a hard mineral that is pale in color and used in industry. The word clue for pyrite is pie, a hard mineral is an old man, and industry is a factory scene. Remember this picture of a pale pie being thrown by an old man in a factory." The students were then asked to describe the picture. Following the presentation of all eight minerals, students were reminded of the retrieval steps and then tested for attribute recall.

Direct instruction condition. Students in the direct instruction condition were initially shown the illustrations and examples for the two practice items. While the experimenter showed a picture, she said, for example: "This is a picture of pyrite. Pyrite is a hard mineral, it is pale in color, and it is used in industry. What is the hardness of pyrite? What color is pyrite? And where is pyrite used? Good! Pyrite is hard, it is pale in color, and it is used in industry." The experimenter then proceeded to take away the picture and repeat the questions, prompting and providing corrective feedback as necessary. After reviewing the two practice items, the experimenter then administered a practice quiz that was similar to the one that the student would have at the end of the session. Immediately following this, the eight target items were presented by the experimenter. Four minerals and their attributes were taught and then reviewed. Following that, the second four minerals were introduced, followed by a review of all eight minerals and their

attributes. Students in this condition received five minutes of direct instruction on the eight minerals and their attributes. The attribute recall test then followed.

Free-study condition. Students in this condition were initially presented with a typed list of the two practice items and associated attributes. The experimenter explained that the typed sheet told the student the name of the mineral, whether it was soft or hard, whether it was pale or dark in color, and whether it was used mainly in the home or in industry. The experimenter then read through the list with the student (e.g., "This is pyrite, it is hard, it is pale in color, and it is used in industry"). The experimenter then proceeded to tell the student a variety of ways that might be helpful for studying. These included reading the list over and over for rehearsal purposes, writing relevant information down, covering up part of the list and self-testing, and using any other methods that (s)he wished. Students were told to try hard, because when they were finished, they would be given a quiz. The students then were allowed to study the two practice items for a short time, followed by a practice quiz on them. Immediately following this, the students were provided the list of the eight target minerals and their associated attributes. They were told that they would be given reading assistance if needed and were then allowed five minutes to study the list. Following this, they were administered the attribute recall test.

All conditions. The total amount of instructional time (8 minutes) was held constant in all three conditions. However, because keyword learning initially took place in the mnemonic condition, it should be noted that students in the direct instruction and free-study conditions received approximately 25% more time than mnemonic subjects specifically learning the minerals and their attributes. In all three conditions, immediately after the eight minerals had been studied, the subjects were asked to write their name, date of birth, grade level, and the name of their homeroom teacher, on an envelope. This "filler" activity consumed 90 seconds. Students were then administered the attribute recall test. On this test, the students were asked in order (mineral by mineral): how hard the mineral was, what color it was, and where it was used. The minerals were presented in a random order different from that of the study list.

Results

Scoring

Responses were scored correct if they consisted of the exact response (e.g., "soft" or "hard" for hardness level) or a synonym (e.g., "light" instead of "pale" for color). Reliability of scoring was assessed at 100% by two independent scorers who were "blind" to the experimental conditions.

The mean percentage of correct attribute classifications is presented in Table 1. For each attribute, "chance" performance is

Insert Table 1 about here

50% assuming that the two relevant attribute category labels were available to all students. (One student in the free-study condition omitted one response, and no subjects produced other attribute responses.) With only eight minerals, this resulted in quite a skewed distribution with reduced variance (i.e., a "ceiling effect") for each attribute in the mnemonic condition. Because of this, and because the profile of conditions differences was similar for all attributes, a total across-attributes score was computed for each subject. This total may be found in the last row of Table 1. Because a ceiling effect is still apparent in the mnemonic condition, pairwise differences between conditions were investigated using a Welch unequal-variance adaptation of the Dunn multiple-comparison procedure based on a familywise alpha of .05 (Kirk, 1982). According to this procedure, all three conditions differed from one another on mean total recall: mnemonic subjects recalled more than did either direct instruction, $t(18) = 8.96$, $p < .001$, or free-study subjects, $t(18) = 5.10$, $p < .001$; and free-study was superior to direct instruction $t(22) = 3.13$, $p < .01$.

Discussion

The results of the present investigation support those of Scruggs et al. (in press) in that strong differences favoring the

mnemonic condition over direct instruction and free study were again found. In addition, the tendency for direct instruction to be worse than free study in the Scruggs et al. (in press) experiment was supported statistically here. Note that with a "chance" level of 50% in the present study, mnemonic subjects are performing near "ceiling," direct instruction subjects are performing near "floor", and free-study subjects are between these two extremes. Clearly, mnemonic instruction was extremely effective for this task, whereas direct instruction was extremely ineffective.

As noted by the Editor of this journal, an argument can be made that the artistic quality of the mnemonic illustrations is superior to the quality of the illustrations used in the direct instruction condition, which may have contributed to the observed recall differences. A glance at the two sets of illustrations certainly suggests that the mnemonic illustration of pyrite (Figure 4) is far more "interesting" than the corresponding nonmnemonic illustration for the direct instruction condition (Figure 6). Simple line drawings were used in the direct instruction condition so that pale vs. dark minerals could be represented with no ambiguity. Moreover, all mineral illustrations were constructed to be easily discriminated from one another. Although the resulting nonmnemonic illustrations appear to be of inferior quality in this study, it should be mentioned that: (a) in a previous experiment where actual color photographs

of the minerals were used (Mastropieri, Scruggs, & Levin, in press b), the performance levels were essentially the same as those reported here; and (b) in earlier studies where mnemonic and nonmnemonic pictures were virtually identical in their construction (e.g., Levin, McCormick, Miller, Berry, & Pressley, 1982; Levin et al., 1983; Mastropieri, Scruggs, Levin, Gaffney, & McLoone, in press), patterns of performance have paralleled those reported here.

The performance advantage of both mnemonic instruction and free study over direct instruction may come as somewhat of a surprise to advocates of direct instruction procedures, which are thought by many to be among the greatest instructional advances in recent years (Karoly & Steffan, 1982). The reason for the performance advantage of the free-study condition is not completely known. However, to the extent that direct instruction --with its experimenter-controlled rote repetition component--is viewed as interfering with the processes students normally invoke to remember this type of information (see, for example, Levin & Pressley, in press; and Rohwer, 1973), then direct instruction might be viewed as actually depressing students' performance relative to free study (rather than free study facilitating performance relative to direct instruction).

Although the present findings do not support direct instruction as an effective learning strategy in the present

context, direct instruction methods have previously been found to be successful under other circumstances (Becker et al., 1982). In fact, as we have argued on the basis of our own research, effective mnemonic instruction shares several of its components with the direct instruction model, with teaching to a specified objective and interaction with the experimenter being the most prominent. In the present context, however, it appears that the three mnemonic R's of recoding, relating, and retrieving are superior to the three operant R's of responding, reinforcement, and repetition (Scruggs et al., in press) that are associated with direct instruction.

A salient difference between mnemonic and direct instruction may be seen in the following example of recalling color attributes (here, pale or dark). In both instructional treatments, objects were either blackened in or not. In the direct instruction condition, unfamiliar mineral representations (e.g., pyrite, crocoite, beryl) were the objects pictured as being either dark or pale, whereas in the mnemonic condition familiar keyword representations (e.g., pie, crocodile, barrel) were the objects so pictured. Contrast the difficulty in subsequently remembering the darkness or paleness of unfamiliar objects, on the one hand, versus familiar objects, on the other. Mnemonic subjects apparently had no difficulty in remembering pictures of pale-colored pies (pyrite = pale), a dark-colored crocodile (crocoite =

dark), and dark-colored barrels (beryl = dark), whereas direct instruction subjects had difficulty recalling the colors of their pictured objects--see Table 1. The difference, of course, is in the direct retrieval path afforded by mnemonic illustrations (mnemonic condition), but not by nonmnemonic illustrations (direct instruction), as has been suggested previously (Levin, 1983).

Although mnemonic instruction with exceptional students has consistently proven effective in the research to date, potential limitations associated with such instruction need to be investigated. For example, and with reference to the Zeus example of Figure 1, might less able students misremember Zeus as a lion? With respect to learning mineral attributues mnemonically, what would happen when several minerals with the same attributes needed to be remembered? How many times can the buns and shoes and trees of the pegword system be reused, or how effective is the keyword method when applied to phonetically similar items? How permanent is the retention of mnemonically acquired content and can mnemonic strategies be (spontaneously) transferred to novel domains? And, is the consequence of applying a mnemonic strategy one of sacrificing "knowledge" or "comprehension" for the rote memorization of facts? Although some of these potential limitations have been addressed in nonhandicapped learners (see, for example, Levin & Pressley, in press), research directed specifically at handicapped learners is obviously needed.

The specific circumstances under which mnemonic instruction and direct instruction will prove most effective, as well as the circumstances under which they might profitably be combined, also need to be explored further. Nonetheless, the present findings add to an accumulating body of literature (Mastropieri, Scruggs, & Levin, 1983) that documents the utility and effectiveness of mnemonic strategies in a number of content domains and with students in several classes of exceptionality. Although much work remains to be done in refining the applications of mnemonic techniques, there appears to be strong evidence at present that they constitute extremely versatile strategies for professionals in the field of special education.

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Footnotes

We wish to acknowledge the cooperation of Dr. Hal McGrady and the special education personnel from the Mesa Public Schools.

We would also like to thank Marilyn Tinnakul, Ursula Pimentel, Roberta LaMont, Mary Ellen Heiner, and Jill Barry for their assistance in the preparation of this manuscript. In addition, we would like to thank Joe Gardner for his artwork. The first author's contribution to this study was funded in part by a postdoctoral fellowship through the Developmental Center for Handicapped Persons at Utah State University, and the last author received funding from the National Institute of Education through the Wisconsin Center for Education Research. Requests for reprints should be sent to Margo A. Mastropieri; Developmental Center for Handicapped Persons: UMC 68; Utah State University; Logan, UT 84322.

[1]A substantial performance advantage of mnemonic instruction over direct instruction in special education settings has also been reported for the vocabulary acquisition of both LD students (Mastropieri, Scruggs, Levin, Gaffney, & McLoone, in press) and EMR students (Scruggs, Mastropieri, & Levin, in press).

Table 1

Mean Percent of Correctly Recalled Attribute Classifications in Each Condition

	Condition		
Attribute	Mnemonic	Direct Instruction	Free Study
Hardness level	89.6	64.6	80.2
Color	95.8	64.6	71.9
Use	99.0	61.5	78.1
Total	94.8	63.5	76.7

Note. For each cell percentage, "chance" is assumed to be equal to 50.0.

Figure Captions

Figure 1. Mnemonic representation for Zeus = king of gods.

Figure 2. Mnemonic keyword-pegword representation for barite = 3 on the hardness scale.

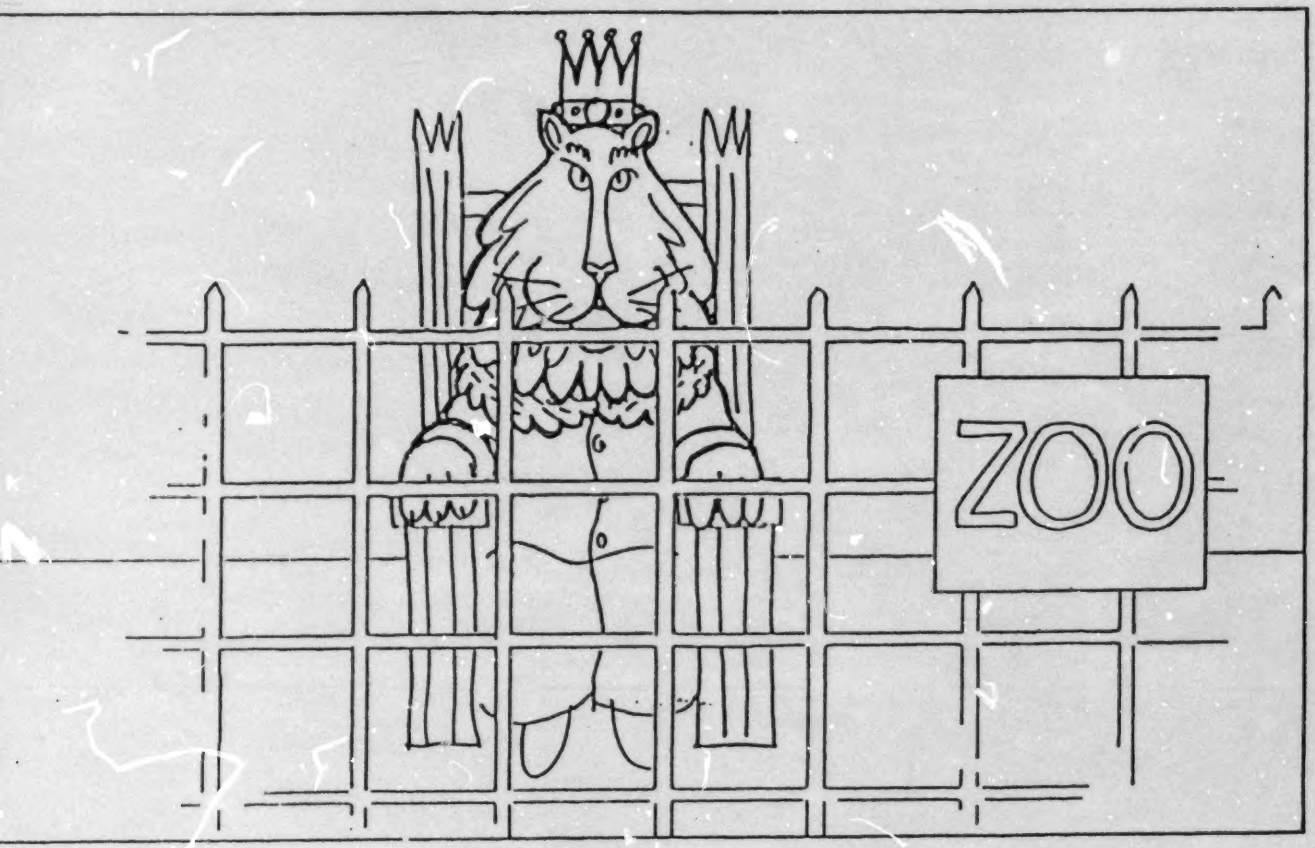
Figure 3. Mnemonic representation of specific attributes for pyrite (pie colored yellow in original).

Figure 4. Mnemonic representation of dichotomous attributes of pyrite.

Figure 5. Mnemonic representation of dichotomous attributes of crocoite.

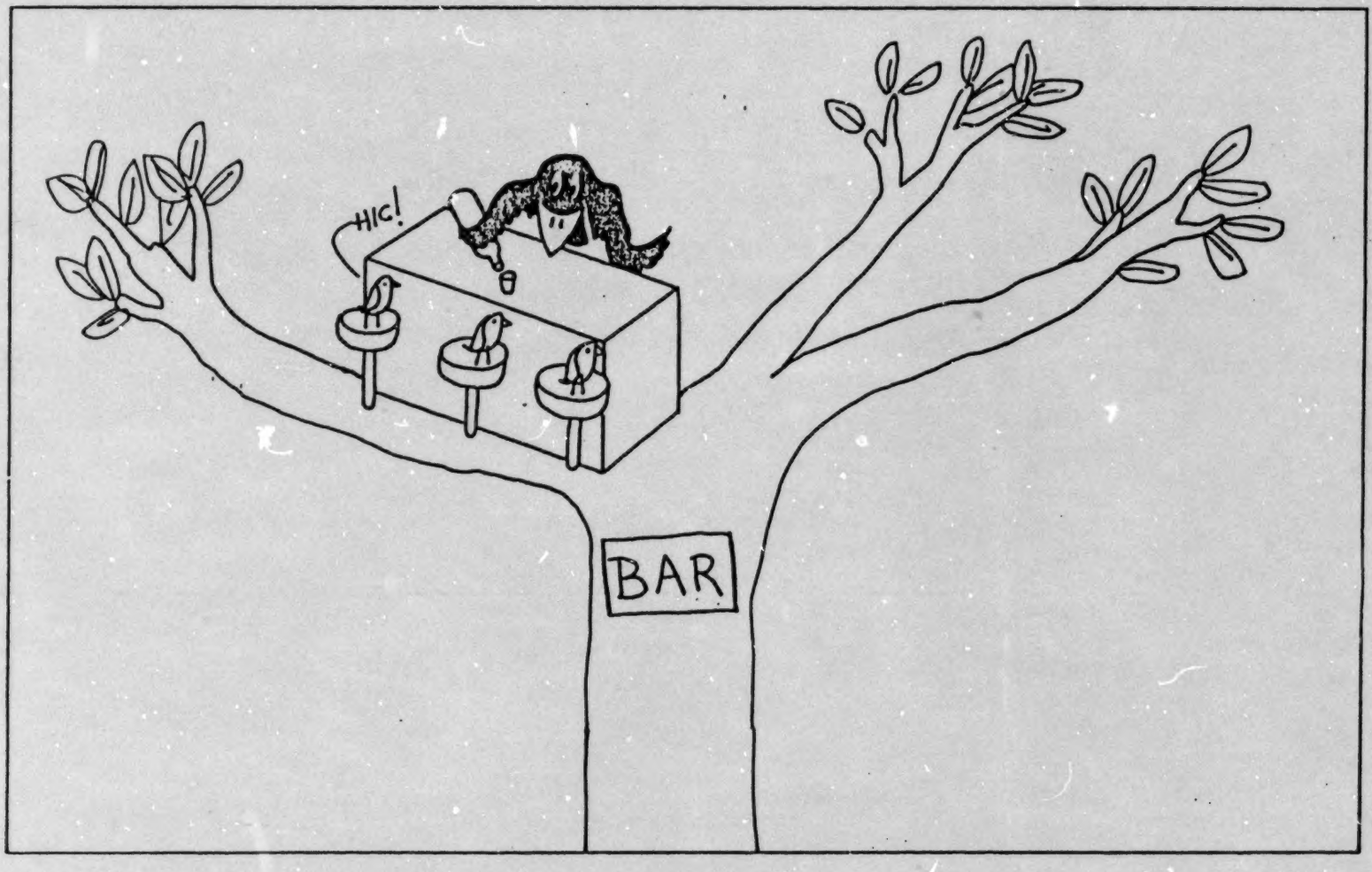
Figure 6. Direct instruction illustration for pyrite (colored yellow in the original).

Zeus (zoo) KING of Gods



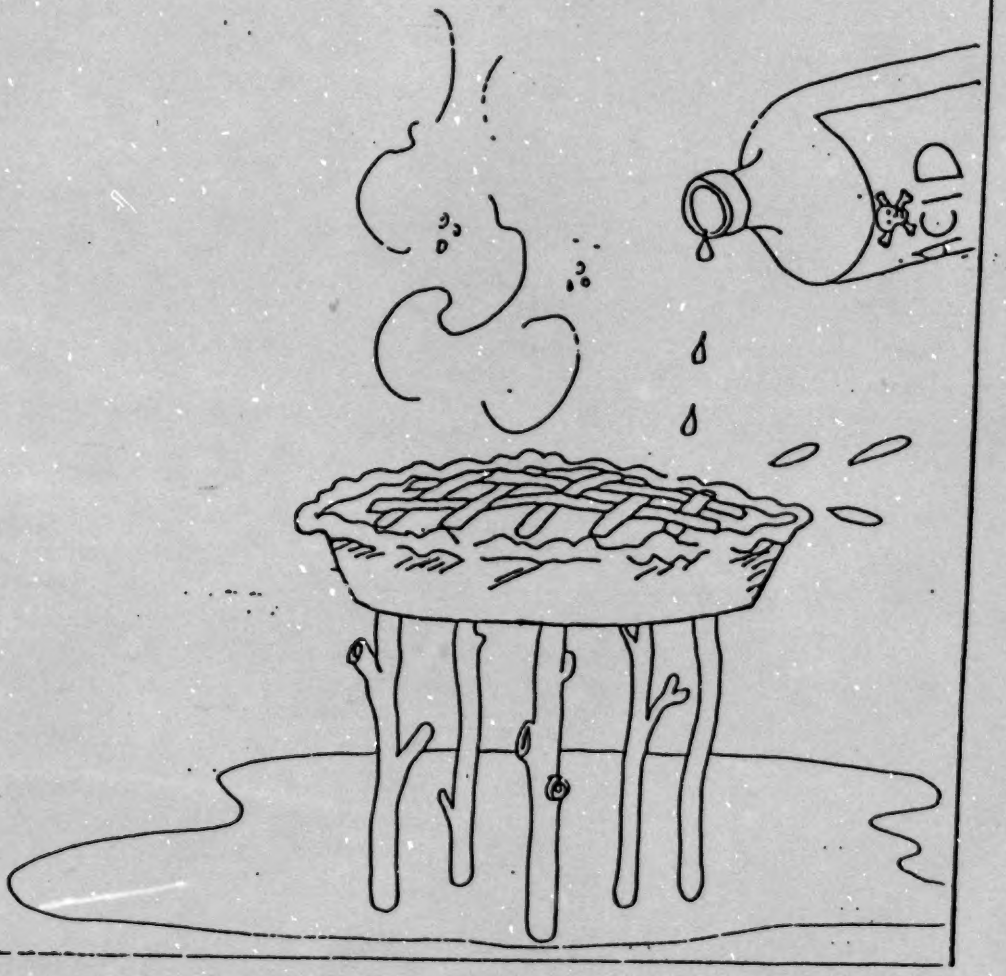
tree

bar

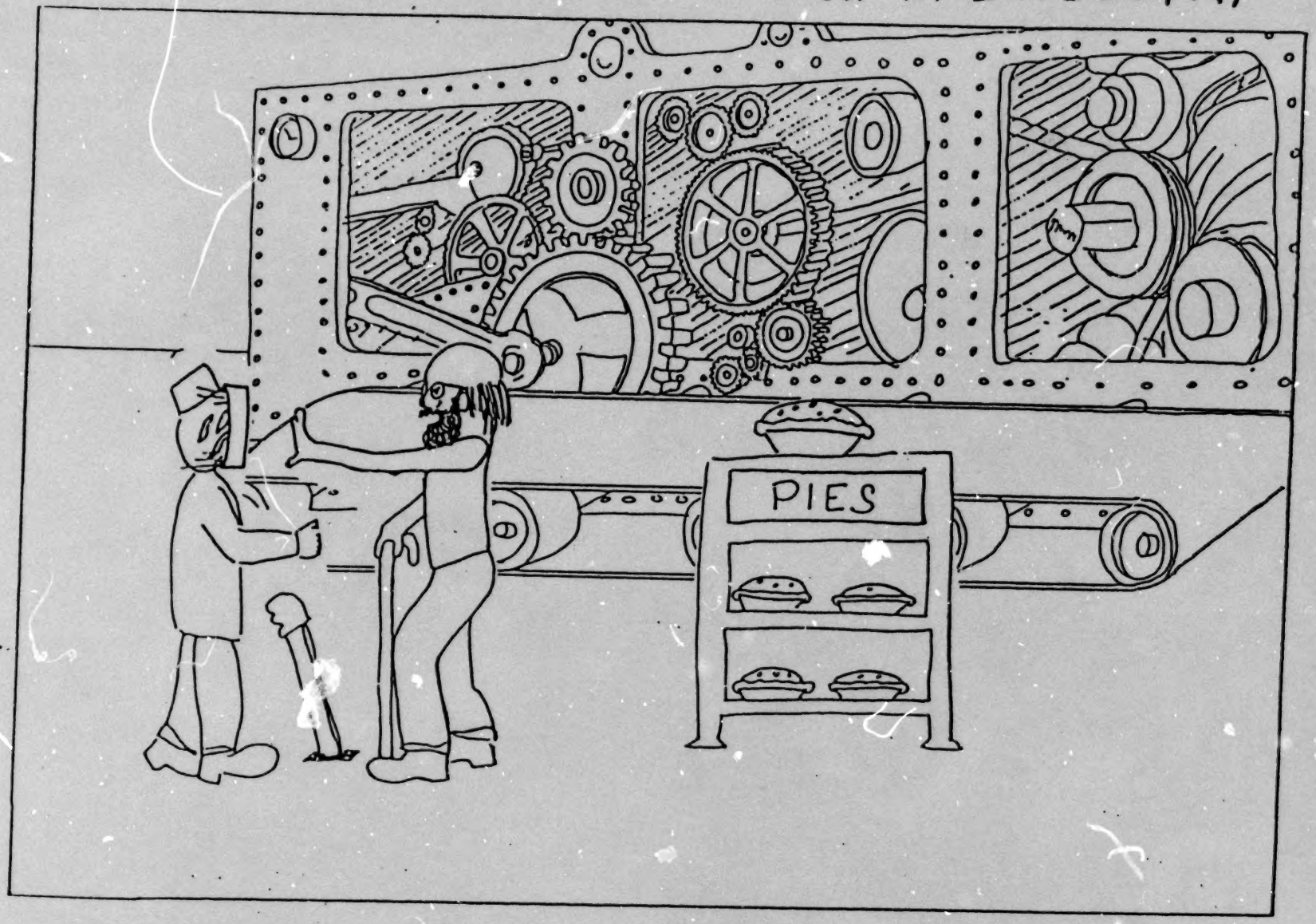


PYRITE (pie)

Hardness Level 6 (sticks)
YELLOW Color
Used for ACID



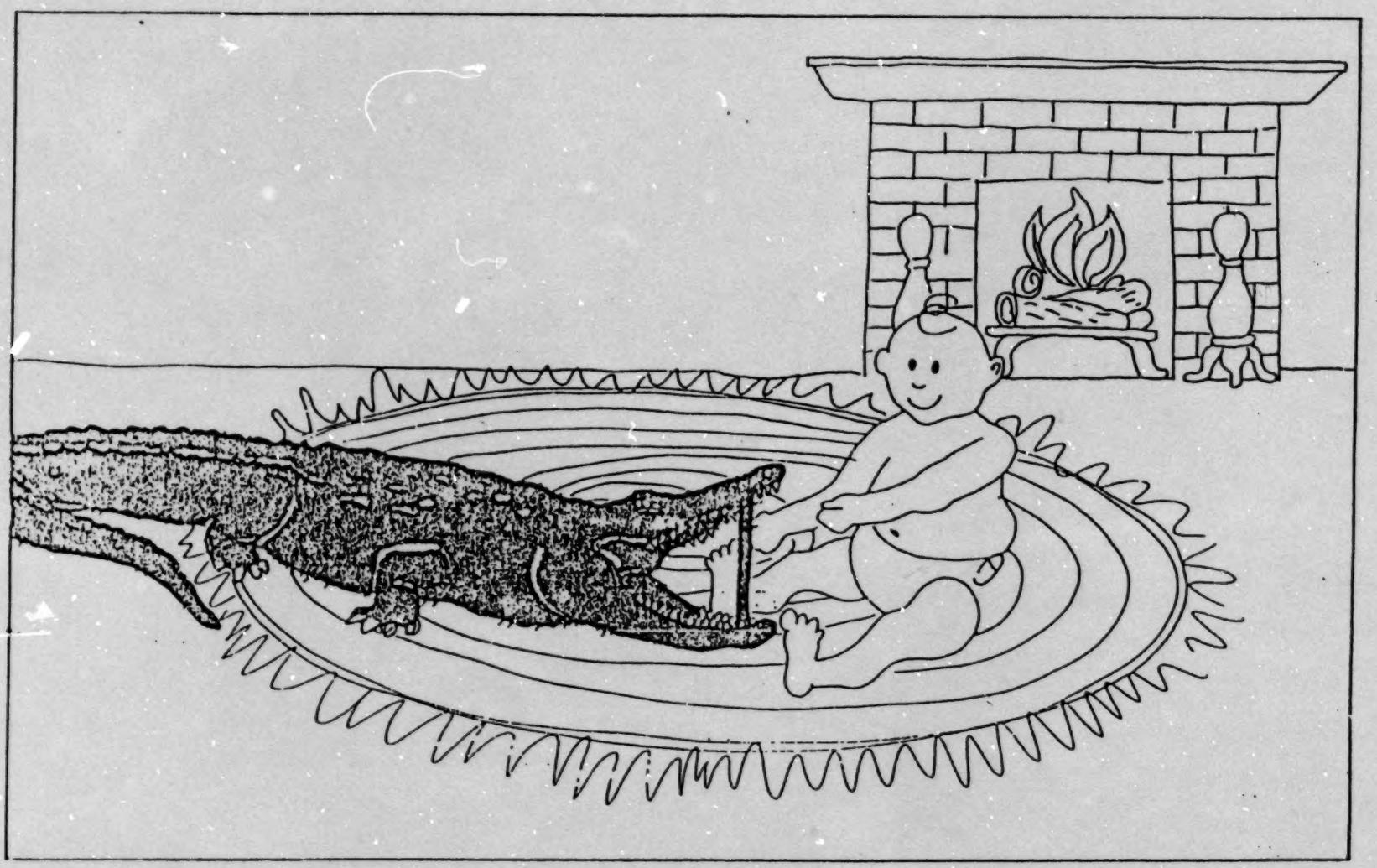
PALE Color
Used in INDUSTRY



BEST COPY AVAILABLE

CROCODILE (crocodile)

DARK Color
Used in HOME



PYRITE

HARD Mineral
PALE Color
Used in INDUSTRY